Space Weather Technical Forecast

Issued on Thursday, 30 December 2021 at 00:47 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight chance of G1/Minor Geomagnetic storm, mainly on Day 3. Chance of Active electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Low with a number of Common-class flares. Five active regions cover the visible disc. The most complex region in the southwest AR2916 produced the most significant flare at 29/0428 UTC. The other previously active region, 2918 in the northwest, is now waning in activity. The other regions are weak and stable. No Earth-directed Coronal Mass Ejections (CMEs) were observed in available imagery during the period.

Solar Wind / Geomagnetic Activity: The solar wind speed as observed by ACE and DSCOVR at L1, was slow-ambient to slightly elevated peaking at 440 km/s at 29/0006 UTC. Density was mostly near average, becoming generally above average from around 29/1500 UTC peaking at 31ppcc at 29/2334 UTC. The IMF was weak for much of the period becoming Moderate from around 29/1900 UTC with a recent peak of 20nT, perhaps due to Earth's connection with the high speed stream (HSS) from CH39/+. The north-south component Bz varied between +11/-5 nT. Finally, the phi angle was positive (away from the sun). Geomagnetic activity was Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) was at background to moderate levels, peaking (just below the active level) at 935pfu at 29/1645 UTC. The fluence rose steadily through the period and observed fluence at 30/0000UTC was 1.82e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low solar activity is forecast to continue throughout the period with a slight chance of further isolated M-class flares, most likely from AR2916 and giving Moderate levels of solar activity. No significant regions are anticipated to rotate onto the visible disc from the far-side during the four-day period.

Solar Wind / Geomagnetic Activity: Earth may experience a glancing blow from a CME on Day 1 (30 Dec), but this is low confidence. Solar winds are likely to remain slightly elevated for much of the period and on Day 3 (01 Jan) a HSS from CH40/+ is likely to arrive to give a rather more enhanced stream. Geomagnetic activity is forecast to be largely Quiet to Unsettled. There is a chance of Active intervals through the period and a slight chance of a G1/Minor Geomagnetic storm, this most likely on Day 3.

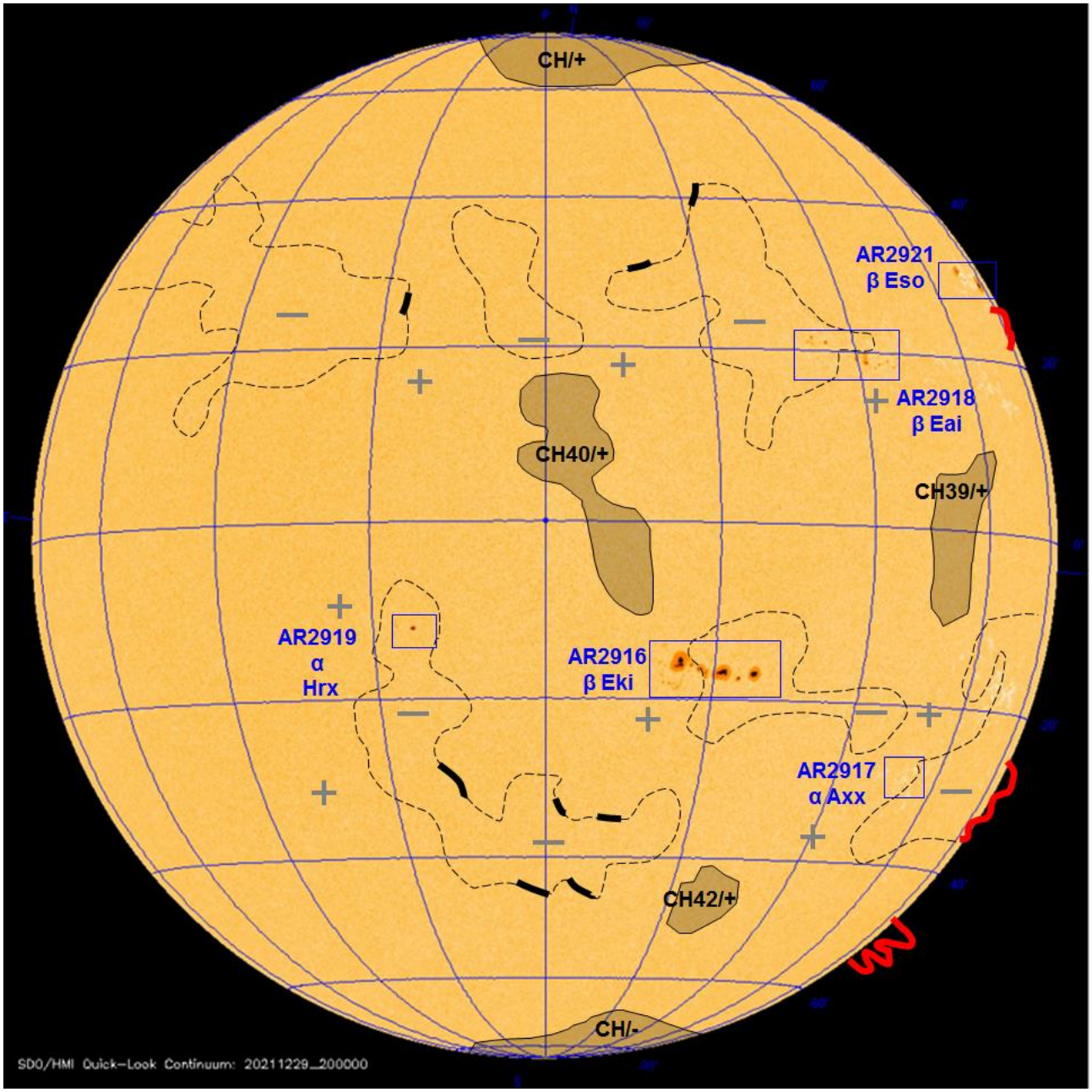
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, albeit with a very slight chance of S1 should there be any significant flare activity. High energy electron flux (greater than 2MeV) levels may reach high

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

levels at the daily maxima before the HSS on Day 3 (01 Jan) arrives and may result in suppression in levels. Fluence levels may rise further through Days 1 and 2, with a chance of reaching the Active threshold, before likely falling on Day 3.

Figure 1. Solar Analysis Valid 2000UTC, 29 December 2021.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

Geomagnetic Storms:

On Day 1 (30 Dec), there is a small chance of peripheral effects from a glancing blow from a coronal mass ejection (CME) emanating from a filament eruption which occurred 26/2012 UTC. This is currently forecast to most likely miss Earth, but confidence is low given some MOSWOC Enlil ensemble members displaying glancing blows at Earth. No other CMEs feature in the current forecast.

The coronal hole forecast for the period is of low confidence due to differences from the previous rotation. STEREO-A data does suggest a slight enhancement in solar wind speeds through Day 1 (30 Dec), but the data is very noisy and difficult to interpret. Solar winds are slightly elevated with a likely connection to the HSS from CH39 now underway. It seems likely that solar winds will remain slightly elevated until Day 3 (01 Jan), when there appears to be a more assured HSS from a persistent coronal hole, CH40/+. Solar winds may approach 500 km/s from this feature.

Geomagnetic activity is forecast to be largely Quiet to Unsettled. There is a chance of Active intervals through the period and a slight chance of a G1/Minor Geomagnetic storm, this most likely on Day 4.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	5	20	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

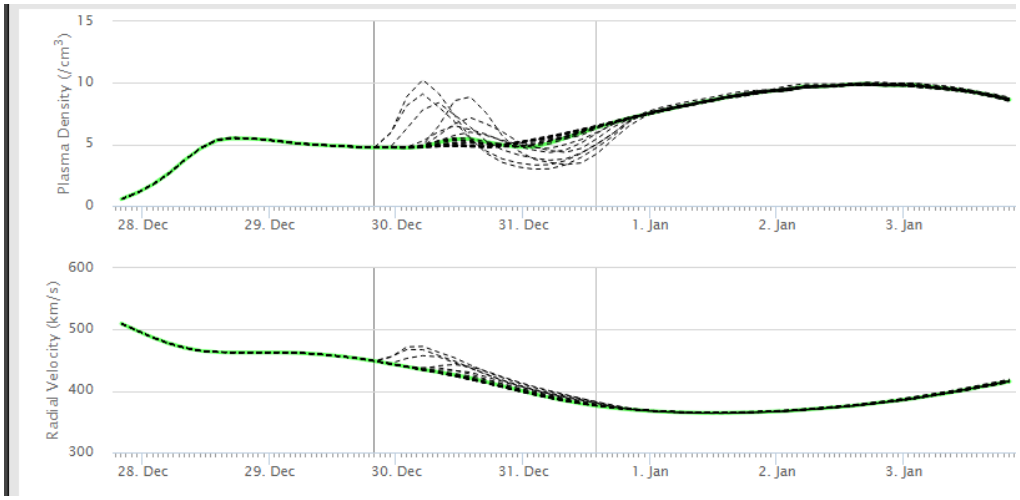
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
27/0418 UTC	N/A	Filament eruption	SW quadrant	500 km/s	Probable miss but minority ensemble members suggest late Thursday	Possible glancing blow

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

Figure 2: Met Office Enlil ensemble model output indicating arrival times of CME.



Radio Blackouts - X-Ray Flares:

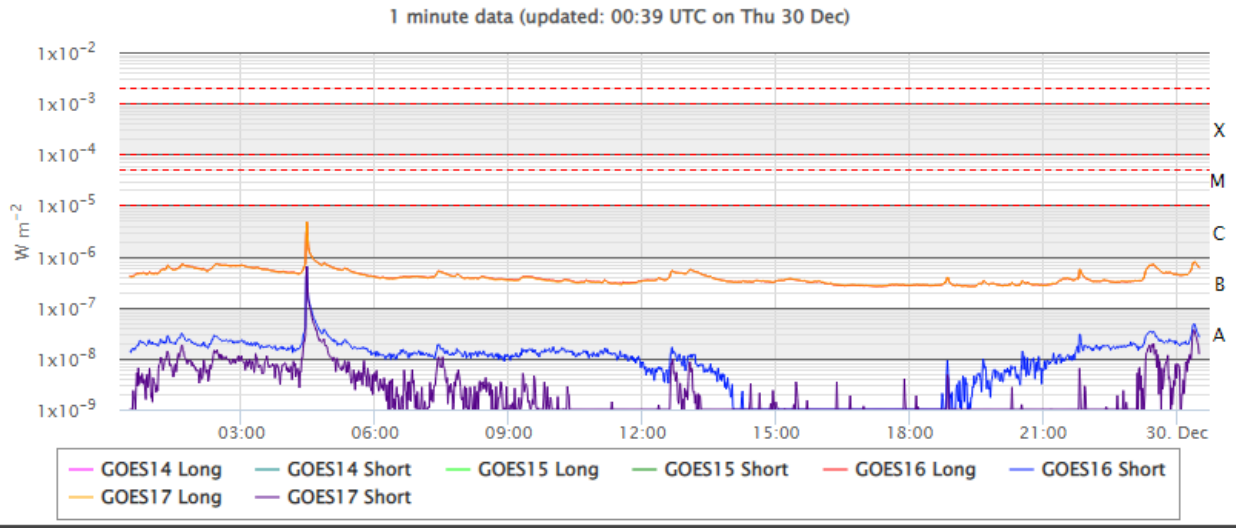
Solar Activity has been Low with a few C-class flares observed in the last 24 hours. Background X-ray flux recorded at GOES-16 continued to show an overall decline. The largest region on the disc, AR2916 (Eki/Beta), is relatively stable and magnetically fairly simple. It did however give the largest C-class flare (C4.6) of the period at 29/0428 UTC. AR2918 is declining steadily in activity. AR2921 in the far northwest is approaching the limb and remains quite a large region but also appears to be magnetically simple and hasn't given any notable flares. The other regions are small and simple.
In terms of overall trends, no major returning regions are forecast over the eastern limb in the coming four-day period and AR2921 will rotate off. This giving a continuing decline in background x-ray levels. Solar activity is expected to be Low, with further C-class flares. There is a daily chance of activity increasing to Moderate levels, with further isolated M-class flares. These are most likely to come from active region 2916.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	20	10	5	1
Very Active	R3 to R5 X Class	No	5	3	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

Figure 3: GOES X-ray flux over past 24 hours with some minor activity.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at background levels and will most likely persist as such. There is a very slight chance of S1 from any notable flares on the disc, probably most likely from AR2916 as they rotate across the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	3	3	3
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

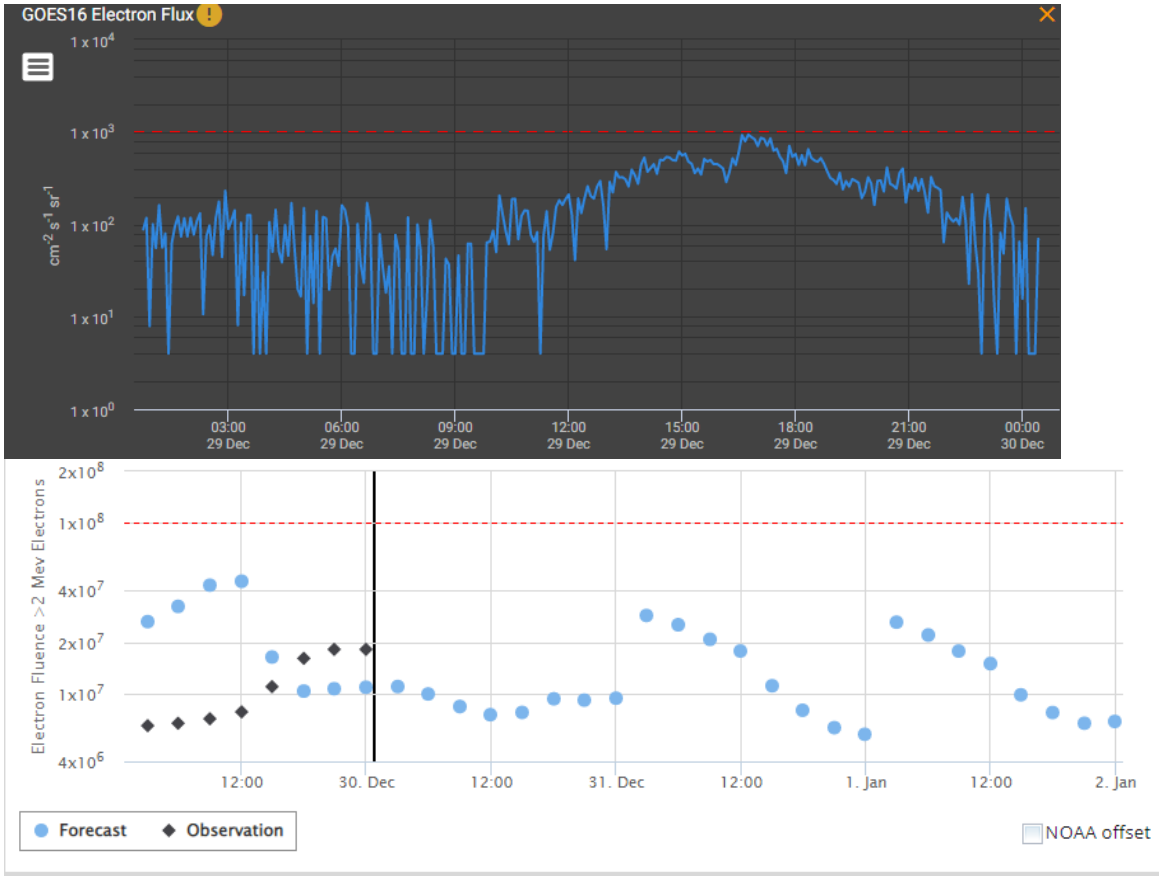
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):
High energy electron flux levels have recently been at background or moderate levels since the high speed stream (HSS) arrival from CH38 or 39. This is likely to be due to compression of the radiation belts from the HSS. As the radiation belts de-compress, it is possible that flux levels will bounce back to reach high levels at the diurnal maxima on Days 1 and 2 (30 and 31 Dec), before another suppression is likely with the next HSS on Day 3.
As such, fluence levels may start to rise again on Days 1 and 2, with a chance of reaching Active levels during this time. REFM is suggesting a rise in fluence, although keeping levels below the Active threshold. This seems to be a good general trend, although there is low confidence in the peak fluence levels expected. The likely flux suppression on Day 3 will then probably result in a decrease in fluence levels at this time.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	20	30	20	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: High energy electron flux and Met Office REFM output over past 24 hours.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.